Space Weather Technical Forecast

Issued on Sunday, 12 November 2023 at 13:12 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: 09 Nov CME arrived at Earth early Day 1 (12 Nov), although weaker than anticipated. Chance of G1 Minor Storm day 1 (12 Nov) and possibly early day 2 (13 Nov). Active electron fluence Expected at Geo, possibly throughout the period.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is Moderate, with a solitary Moderate-class flare, peaking M1.2 at 11/1729 UTC from AR3477 (Dso/Beta).There are currently four numbered sunspot regions on the visible disc, with one unnumbered region, which has recently emerged south-centre disc. AR3483 (Dhi/Beta-Gamma) remains the largest group, although it appears to have lost its delta spots. The numerous intermediate spots have largely consolidated into a larger trailer spot. AR3484 (Csi/Beta) and AR3485 (Cao/Beta) showed continued proliferation of their numerous small spots. AR3477 (Dso/Beta) remains relatively unchanged and stable. A new and currently unnumbered sunspot region has rapidly developed in the south-centre disc, which is currently a Dso/Beta configuration. No Earth-directed CMEs have been observed in the past 24 hours.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by ACE and DSCOVR, were reflective of the waning effects from a high speed stream associated with CH67/-. Solar wind speeds were Elevated to Slightly elevated, ranging from 500km/s and declining to 440km/s during the first half of the period. However, a CME which left the Sun on 09 Nov arrived at Earth at 12/0530UTC, which was later than anticipated, with wind speeds increasing and peaking near 600km/s at around 12/0730UTC. Density was mostly below average to average, with a peak of 10ppcc at present, as Earth enters the magnetic cloud of the CME. The total interplanetary magnetic field strength (Bt) was steady at or below 3nT to start the period, before increasing to a peak 8nT at 12/0700 UTC, after the arrival of the CME. The all important north-south component (Bz) was steady at neutral or weakly positive at +2nT, before trending weakly negative with the CME arrival, reaching a modest -6nT. The phi angle remained predominantly negative (towards the Sun), with some variation to positive (away from the Sun) during the arrival of the CME. The net result of the above solar wind measures was for mostly Quiet (Kp 0-2) geomagnetic indices, with an Unsettled to Active interval observed 12/0600-0900UTC due to weak CME influences.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at background levels.

GOES16 high energy (greater than 2MeV) electron flux showed a diurnal oscillation at persistently High levels, peaking at 4370pfu at 11/1710 UTC. The associated 24-hour fluence gradually increased through the period, with the fluence observation at 12/0001UTC being 2.33e8 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate, with a chance of further isolated M-class flares on days 1 and 2 (12 and 13 Nov), reducing to a slight chance on days 3 and 4 (14 and 15 Nov).

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Solar Wind / Geomagnetic Activity: Solar winds are currently at elevated levels, near 550km/s, due to the effects of the CME, which arrived Day 1 (12 Nov), later than anticipated. Geomagnetic conditions have been mostly Quiet to Active so far, although there is a Chance of a G1/Minor Storm, given any prolonged negative (Bz) component. Geomagnetic conditions becoming mostly Quiet days 2 and 3 (13-14 Nov), before a possible glancing blow from a CME, which left the Sun on the 10 Nov, arrives during day 4 (15 Nov), which may increase geomagnetic conditions to Unsettled or Active, with a slight chance of G1/minor storm.

Energetic Particles / Solar Radiation: There is a daily very slight chance of S1 or greater radiation storm conditions should any of the western solar hemisphere sunspot groups produce significant flares during the period. This risk should begin to wane from the start of the next working week as these sunspots progress onto the far side. No returning regions are expected to come around from the east limb in the coming days.

High energy electron flux (greater than 2MeV) is expected to continue near current (High) levels at diurnal peaks, temporarily reducing to Moderate levels, after the arrival of the 09 Nov CME. The impacts of the CME on geomagnetic conditions has been relatively weak thus far, which gives low confidence on the behaviour of electron flux in the coming days. Electron flux levels could remain at Moderate to High levels, especially at diurnal peaks. Active fluence is Expected day 1 (12 Nov) and possibly surviving into days 2 and 3 (13-14 Nov), before possibly reducing on day 4 (15 Nov), if a glancing blow from a CME arrives.

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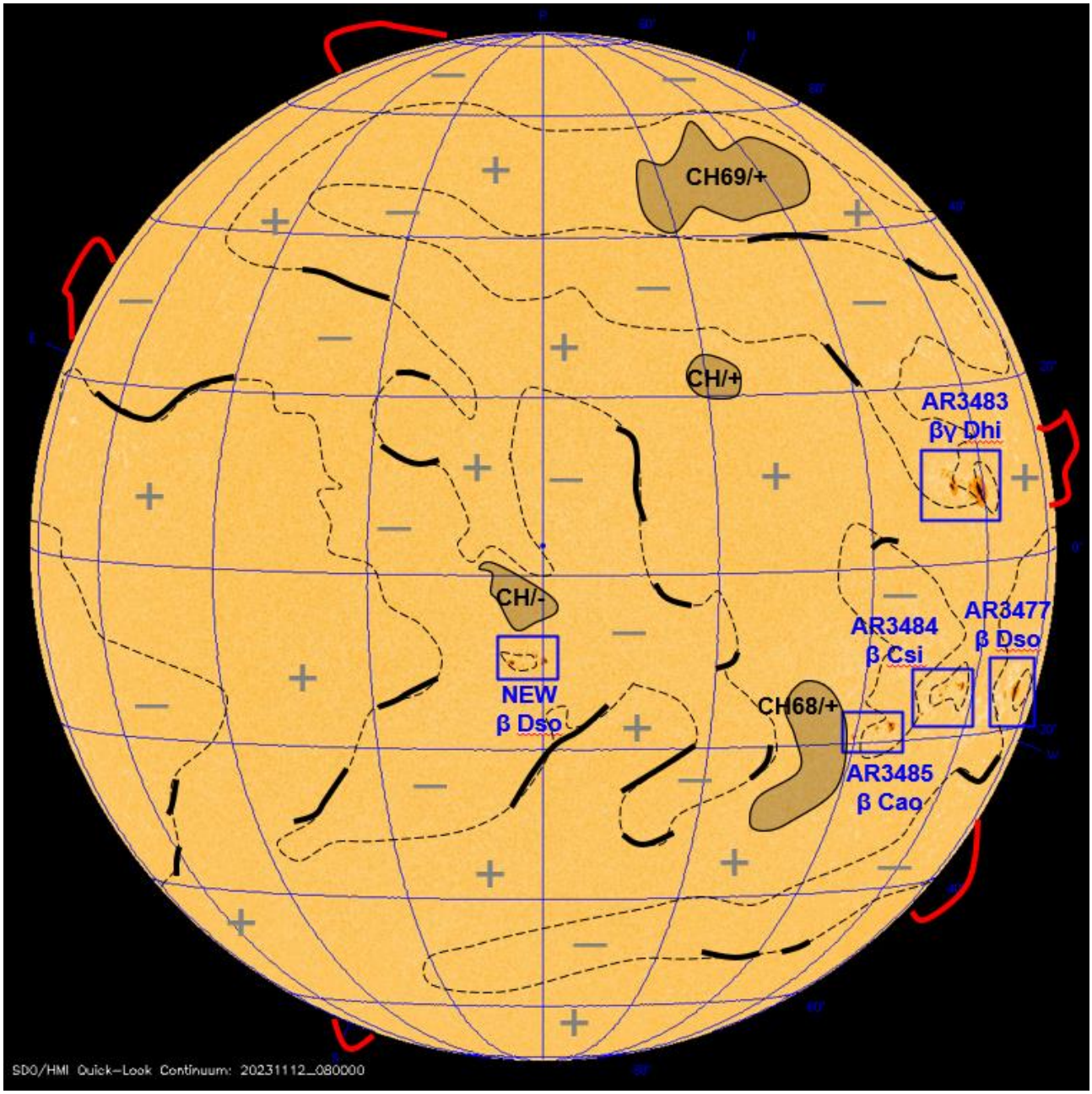
Figure 1. Solar Analysis Valid 12/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The full halo CME which left the Sun on 09 Nov arrived at Earth at 12/0530UTC, later than anticipated. However, there was some uncertainty with this feature due to the very narrow perspective offered by STEREO and LASCO viewpoints at the time of analysis.

A faint and slow CME was observed leaving the Sun late on 10 Nov. The source region of this CME appears to be an eruption in the southwest quadrant in the vicinity of the trio of sunspots (AR3477, AR3484 and AR3485). Initial modelling suggests that the bulk of the CME will miss ahead of Earth orbit, however there is a chance of a glancing blow on day 4 (15 Nov) with limited impacts expected.

The CME, thus far, has been relatively weak, with a limited shock upon its arrival at L1. Geomagnetic activity has been mostly Quiet, with an Active interval observed at 12/0600-0900 UTC as the CME arrived at Earth. Geomagnetic conditions are Expected to be Unsettled to Active (Kp3-4), with a G1/Minor Storm (Kp 5) likely on day 1 (12 Nov) perhaps into early day 2 (13 Nov), gradually waning. Quiet or Unsettled activity is then expected, but with a very slight chance of Active or G1 geomagnetic storms should the glancing blow CME from 10 Nov arrive at Earth on day 4 (15 Nov).

Separately from any CME effects, the persistence forecast comprises of largely Quiet geomagnetic conditions, with no further significant recurrent or transient coronal hole features of note expected during the period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	60	20	1	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
11/0633UTC	Partial	Vicinity of AR3480, AR3484 and AR3485	Central SW	378km/s	15/1200 UTC	Chance of a glancing impact. Low confidence, but limited impacted expected

Figure 2: MOSWOC Enlil model (top) and Ensemble (bottom) shows a possible weak CME (which left the Sun late on 10 Nov) giving a glancing blow at Earth on day 4 (15 Nov).

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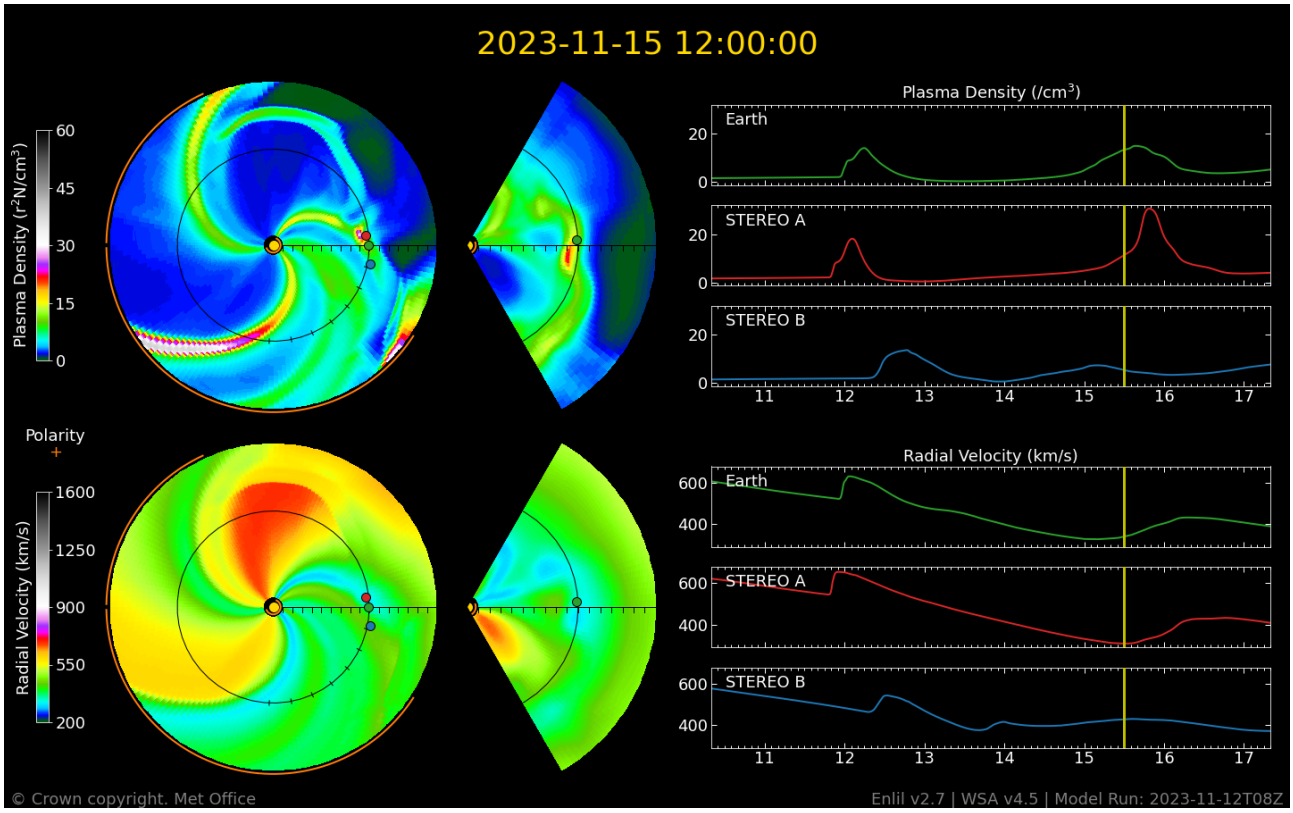

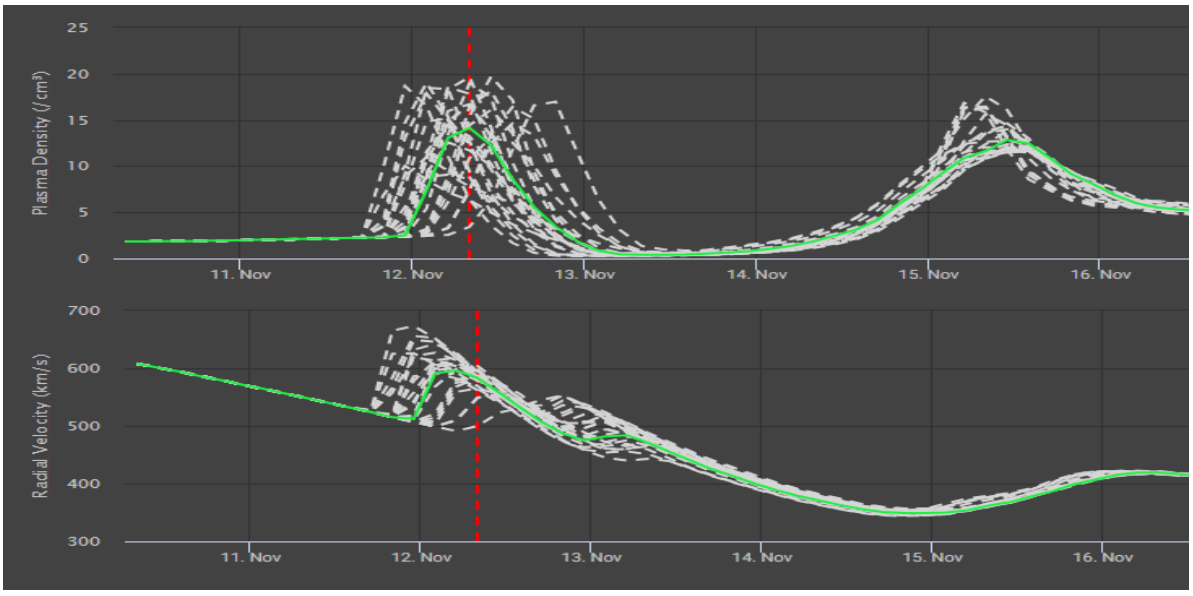

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Radio Blackouts - X-Ray Flares:
There are currently five sunspot regions on the disc. AR3483 (Dhi/Beta-Gamma) in the northwest remains the largest group. There has been some proliferation and spreading of its intermediate portion and the numerous small umbra present have consolidated into a larger trailer spot. The region also contains a Beta-Gamma magnetic configuration.

A complex of three regions lies in the southwest within a broad region of plage. These regions, AR3477, AR3484 and AR3485 appear to be magnetically connected. For the most part these groups appear rather simple and small, however, there has been occasional proliferation of small pores or spots, particularly with AR3484 and AR3485 that bear watching for any further development.

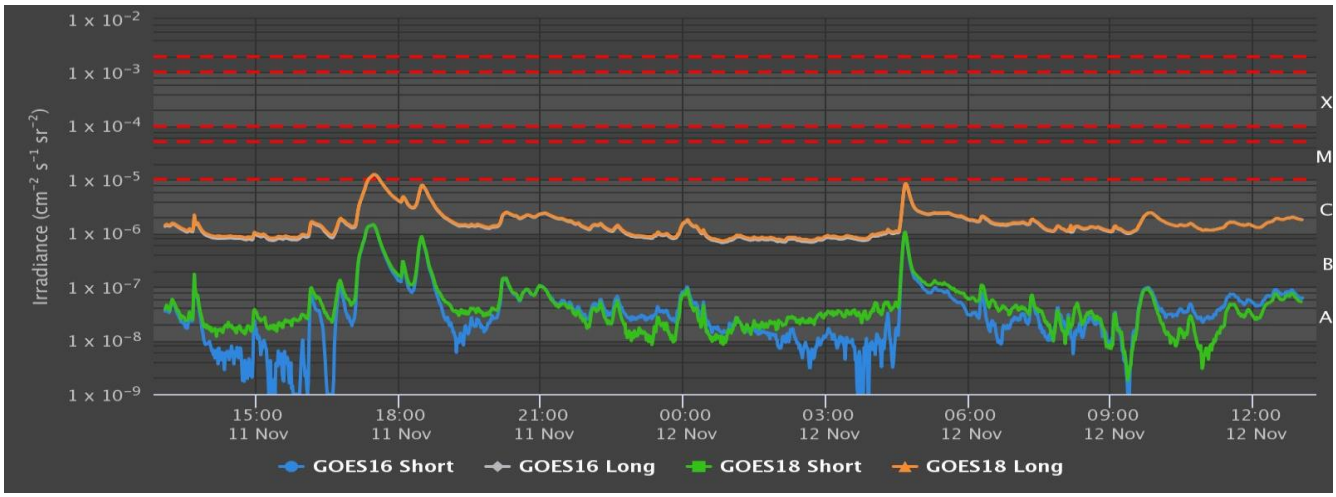
A new and currently unnumbered sunspot region has recently developed near south-centre disc, which appears to be a Beta/Dso configuration at present. This region will continue to be monitored for any further development.

In terms of the overall balance of front-side region populations, AR3477 should depart later on day 2 (13 Nov) to offer a slight downturn in M-class flare risk, followed by AR3483 on day 3 (14 Nov) and AR3484 on day 4 (15 Nov), further reducing probabilities, pending any further development of the recently emerged new sunspot region.

Far-sided soundings, persistence and flux looping all suggesting limited contributions from any returning regions over the eastern limb during the period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	25	25	20	15
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: GOES X-Ray flares



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is at background levels. There is considered to be a very Slight Chance of S1 of greater radiation storm conditions during the period, owing to the numerous sunspot regions currently located in the western hemisphere. Probabilities then begin to wane from the start of the next working week as the cluster of front-side sunspots begin to cross onto the far side. Currently, there are unlikely to be any returning ex-regions from around the east limb.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	10	10	5	5
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has been at High levels over recent days in response to the fast wind from CH67/-. However, the arrival of the 09 Nov CME briefly reduced electron flux levels to Moderate early on day 1 (12 Nov), although the impacts from the CME, thus far, have been relatively weak, allowing electron flux to return to High levels.

Low confidence in the behaviour of the electron flux in the coming days, but given the current muted geomagnetic activity from CME arrival early on day 1 (12 Nov), electron flux levels are likely to remain at High levels, especially at diurnal peaks, over the coming days.

Given the lack of geomagnetic response from the recent arrival of the 09 Nov CME, Active electron fluence is Expected to continue on day 1 (12 Nov), and is now likely survive over the coming days, but with low confidence. Possibly a reduction by day 4 (15 Nov) due to a glancing blow from a CME (left the Sun on 11 Nov).

MOSWOC REFM is not felt to be a useful guide in this instance given the overwhelming reliance of the forecast on recurrent activity.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ 2 MeV ≥ $1x10^8$	Yes	100	70	50	30
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

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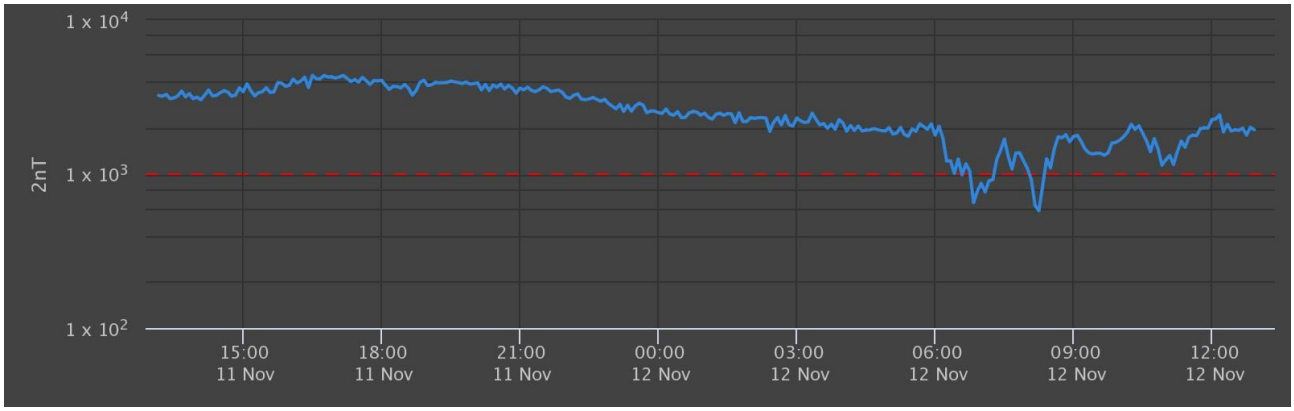
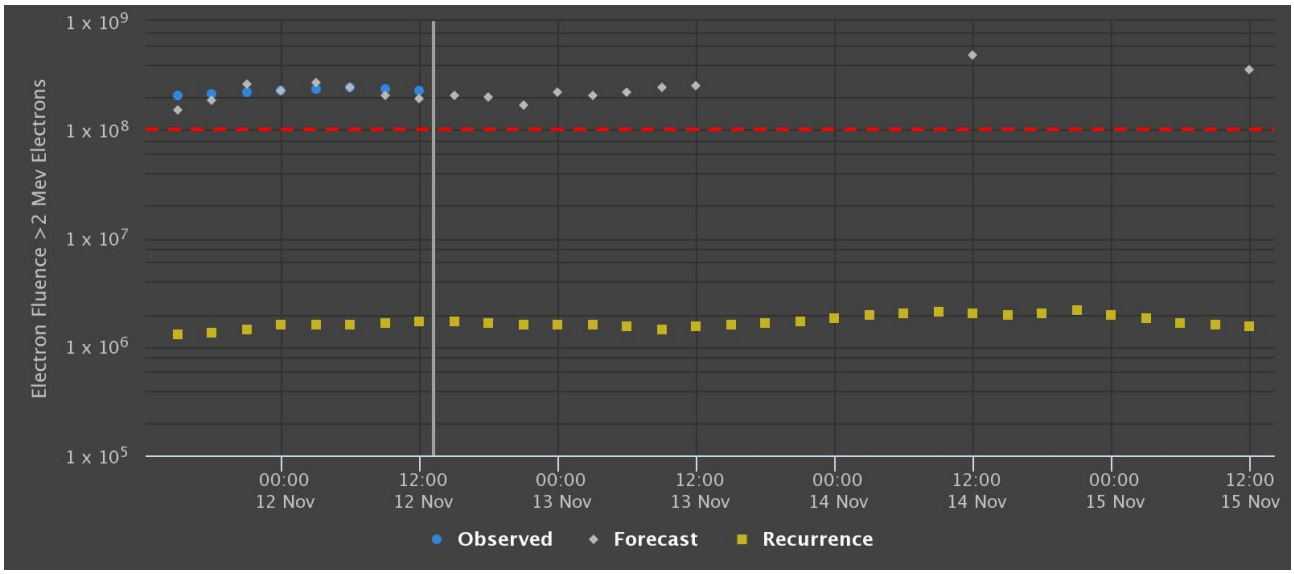
Figure 4: GOES-16 Electron Flux (top) and Electron Fluence (bottom) – currently at High or Active levels.





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